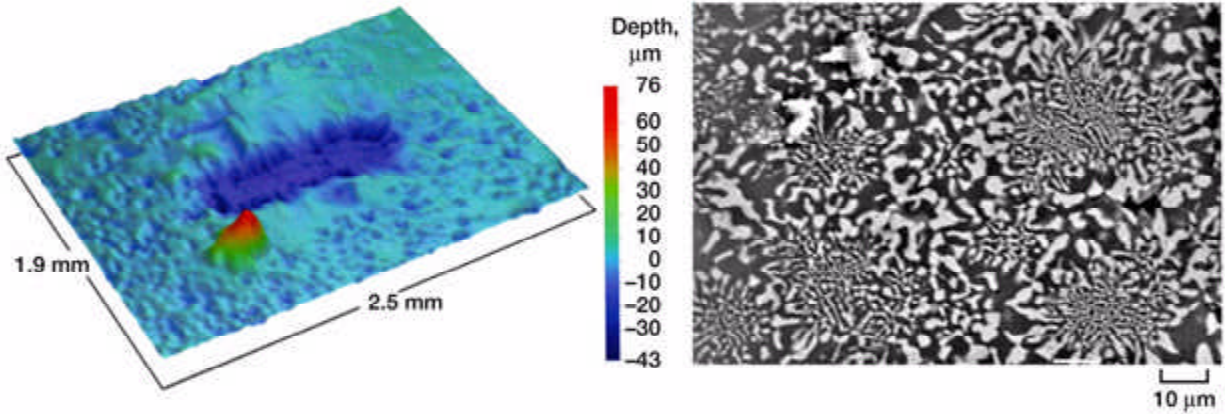
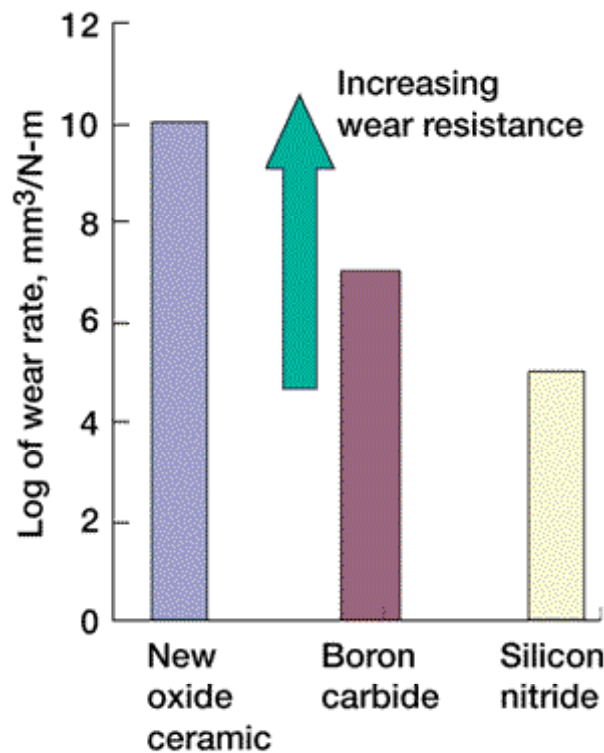


New Oxide Ceramic Developed for Superior High-Temperature Wear Resistance



Wear track of new oxide ceramic material on B4C. Left: Three-dimensional interactive display of B4C showing track. Right: Photomicrograph of new oxide ceramic.

Long description Left: The wear track (groove) on flat B4C introduced from the oxide ceramics during a reciprocating wear test; 200,000 passes in humid air. Right: Scanning electron micrograph of the polyphase microstructure at the contact area; very little wear damage and lifting is observed following the reciprocating wear test with 200,000 passes in humid air. White particles at the top left corner are wear debris particles and small fracture pits within the Al_2O_3 phase (at the middle right of the picture in black).



Comparison of wear resistance at 600 °C for various materials.

Long description New oxide ceramic material exhibits 3 to 5 orders of magnitude increase in wear resistance in comparison to the current state-of-the-art materials (boron carbide and silicon nitride).

Ceramics, for the most part, do not have inherently good tribological properties. For example friction coefficients in excess of 0.7 have been reported for silicon nitride sliding on silicon nitride or on bearing steel (ref. 1). High friction is always accompanied by considerable wear. Despite their inherently poor tribological properties, the high strength and high toughness of silicon nitride (Si_3N_4) ceramics has led to their successful use in tribological applications (refs. 1 to 4). The upper temperature limit for the application of Si_3N_4 as wear-resistant material is limited by reaction with the tribological environment (ref. 3). Silicon nitride is known to produce a thin silicon dioxide film with easy shear capability that results in low friction and low wear in a moist environment (ref. 5). At elevated temperatures, the removal of the reaction product that acts as lubricant causes the friction coefficient to increase and, consequently, the wear performance to become poor. New materials are sought that will have wear resistance superior to that of Si_3N_4 at elevated temperatures and in harsh environments.

A new class of oxide ceramic materials has been developed with potential for excellent high-temperature wear resistance. The new material consists of a multicomponent oxide with a two-phase microstructure, in which the wear resistance of the mixed oxide is significantly higher than that of the individual constituents. This is attributed to the strong

constraining effects provided by the interlocking microstructures at different length scales, to the large aspect ratio of the phases, to the strong interphase bonding, and to the residual stresses. Fretting wear tests were conducted by rubbing the new ceramic material against boron carbide (B_4C). The new ceramic material produced a wear track groove on B_4C , suggesting significantly higher wear resistance for the oxide ceramic. The new material did not suffer from any microstructural degradation after the wear test. The wear rate of the new ceramic material at 600 °C was determined to be on the order of 10^{-10} mm³/N-m, which is 3 to 5 orders of magnitude lower than that for the current state-of-the-art wear-resistant materials (Si_3N_4 and B_4C). The friction coefficient of the new ceramic materials is on the order of 0.4, which is significantly lower than that of silicon nitride.

This new class of oxide materials has shown considerable potential for applications requiring high wear resistance at high temperatures and in harsh environments. New understanding of the wear behavior of ceramic materials is emerging as a result of the surprisingly high wear resistance of two-phase oxide ceramics. There is excellent potential for further improvements in the wear resistance of oxide ceramics through optimizing the microstructure and altering the crystallographic properties of specific oxide materials as a second phase to reduce the coefficient of friction at elevated temperatures.

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